NASA TECH BRIEF

Ames Research Center

Improved Format for Radiocardiographic Data

Radioactive-tracer techniques are not widely used for obtaining cardiac output and heart volume in spite of the obvious advantages to both the physician and the patient. At present, the more hazardous technique involving cardiac catheterization and radio-opaque dyes is favored partly because of a reluctance to accept the somewhat tedious combination of analytic and graphical manipulation required to obtain useful data on cardiac output by the radiographic technique.

The technique employed for collecting the basic data required for radiocardiography involves the introduction of a small (1 cc, 10 μCurie) radioactive sample into the antecubital vein of a supine patient, while flow in the vein is occluded by a tourniquet on the proximal side of the puncture. After injection, the arm is raised and the tourniquet released to accelerate flow of the sample into the right atrium. A scintillation crystal mounted in a collimating housing is placed on the patient's chest in such a manner that its view angle includes a portion of the right heart and a portion of the left heart. As the radioactive sample passes through the heart, the counting rate measured by the crystal is recorded on a strip chart. The recording is continued until the radioactive material is evenly distributed throughout the blood volume. Since the equilibrium counting rate is measured by the crystal while it views precisely the same portions of the heart as those viewed during the first pass of the sample through the heart chambers, the initial data can be compared to the equilibrium rate to provide a calibration of the system, thereby making the data insensitive to geometric effects and other parameters, such as the amount of radioactive material used.

The typical counting-rate curve is the summation by the crystal of rate-data collected from those portions of the right heart, left heart, and coronary bed within the crystal's field of view. Techniques used for separating the individual contributions are based on the assumption that decay of the individual counting rates follows an exponential law, and the application of a factor (relating the ratio of the total volume of blood through which the radioactive sample has been dispersed to the volume of the heart chamber) to determine the exponential rate for each particular case. The superposition of "noise" on an additive set of four exponential rises (right heart, left heart, coronary bed, and recirculation) complicates the construction of the decaying portion of the curve to obtain total area and also complicates diagnosis from visual inspection. Inaccuracies in reconstructing the individual curves have a negligible effect, however, when the data used solely to obtain cardiac output are treated by a self-calibrating method which relates cardiac output to the measured rate data by the formula $F = E/A \times BV$, where E = final equilibrium counting rate, A = area under the rate–time curves, and BV = blood volume of the patient.

The usual method of plotting a time-dependent function, such as counting rate, involves plotting the function on a logarithmic scale against time on a linear scale; this results in a linear decay curve but causes an accentuation of the curvature of the rise. It has been found that a curve in the form of a series of straight-line segments can be constructed by plotting the function linearly against the logarithm of time. The exponentially rising and decaying functions are similar on such a plot, asymptotically departing from

(continued overleaf)

the horizontal near zero time, changing linearly in the midsection, and asymptotically returning to the horizontal for large times. Since the data from clinical curves fit straight-line segments, the localized non-linearities for very small and very large times are of no practical significance.

The formula for cardiac output, $F = E/A \times BV$, requires three factors: E is obtained directly from the crystal detector after the injected sample has been uniformly distributed in the blood. Blood volume (BV) can be obtained from a comparison of the counting rate of the total radioactive tracer before it is administered and the counting rate of a measured sample of blood withdrawn after the tracer has been uniformly mixed throughout the blood stream. The remaining factor, A (the area under the rate–time curve contributed by the right and left hearts and by the coronary bed), is determined with the aid of a simple analytic expression based on parameters that are derived directly from the graph plotted as straight-line segments.

The improved data format also permits simple determination of the individual peak heights of the right heart, left heart, and coronary bed, as well as the determination of the area under the individual "flow triangles."

Note:

Requests for further information may be directed to:

Technology Utilization Officer
Ames Research Center
Moffett Field, California 94035
Reference: TSP 73-10270

Source: John Dimeff and Gunnar Sevelius
Ames Research Center
(ARC-10742)